UNIVERSITI PUTRA MALAYSIA

ASSESSMENT OF GREEN-LIPPED MUSSEL PERNA VIRIDIS (LINNAEUS) AS A BIOMONITORING AGENT OF CADMIUM, COPPER, MERCURY, LEAD AND ZINC FOR THE WEST COAST OF PENINSULAR MALAYSIA

YAP CHEE KONG

FSAS 2003 59

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By

YAP CHEE KONG

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Doctor of Philosophy

February 2003

DEDICATION

This doctoral thesis is especially dedicated to the following most patient persons in my life who made the impossible, possible.

My parents,

brother and sisters,

and my fiancée (Miss Choh Mew Seong).

This doctoral degree is also dedicated to the departure memory of my grandmother.

Thanks to God.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Doctor of Philosophy

ASSESSMENT OF GREEN-LIPPED MUSSEL *PERNA VIRIDIS* (LINNAEUS) AS A BIOMONITORING AGENT OF CADMIUM, COPPER, MERCURY, LEAD AND ZINC FOR THE WEST COAST OF PENINSULAR MALAYSIA

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Chairman : Associate Professor Ahmad Bin Ismail, Ph.D.

Faculty : Science and Environmental Studies

Sediment samples (46 sites) and green-lipped mussels *Perna viridis* (L.) (19 sites) from the west coast of Peninsular Malaysia were sampled between 1998 and 2001 and were analyzed for Cd, Cu, Hg, Pb and Zn. The mean levels of the metals in the west coast (offshore : intertidal) sediments were 0.75 ± 0.06 : 0.86 ± 0.11 µg/g dry weight (dw) for Cd, 4.27 ± 0.36 : 29.22 ± 8.84 µg/g dw for Cu, 38.87 ± 2.93 : 60.10 ± 9.47 ng/g dw for Hg, 17.36 ± 0.99 : 23.32 ± 3.39 µg/g dw for Pb and 37.22 ± 2.01 : 84.64 ± 12.62 µg/g dw for Zn. The metal levels in the soft tissues (ST) of *P. viridis* were found to be 0.25-1.35 µg/g dw for Cd, 6.31-20.21 µg/g dw for Cu, 20.00-152.00 ng/g dw for Hg, 1.27-8.76 µg/g dw for Pb and 53.82-135.50 µg/g dw for Zn. All these metal levels were relatively low in comparison with previously published regional data. In general, the metal levels were higher in the intertidal sediment than in the offshore sediment. Geochemical studies in the sediments revealed that about 58.6 : 57.7% for Cd, 53.3 : 46.3% for Cu, 72.6 : 54.3% for Pb and 34.5 : 48.7% for Zn, in the offshore and intertidal sediments, respectively, were most likely due to anthropogenic sources. Localized elevations of heavy metals in a few locations indicated that the offshore and intertidal areas of the west coast of Peninsular Malaysia were likely to have received anthropogenic metals.

By using the protein level allozyme approach, the genetic differentiation among the different geographical populations of this species fell within the range for conspecific populations. Since *P. viridis* populations are sedentary, widely distributed in the west coastal area of Peninsular Malaysia and have low genetic differentiation, the species generally is a good biomonitoring agent for heavy metals in the area. The mussel *P. viridis* collected from the field also showed that the metal concentrations in its total ST were positively and significantly ($P < 0.05$) correlated with Cd, Cu and Pb in the environment as represented by the sediment samples.

The suitability of *P. viridis* as a biomonitoring agent for heavy metals was experimentally studied. The results of the laboratory experiments showed that the ST of *P. viridis* was readily capable of accumulating heavy metals especially Cd, Pb and Hg to elevated levels. Depuration studies also showed that the metal levels in different STs were significantly ($P < 0.05$) correlated with those of the seawater. By using endpoints mortality, filtration rate (FR) and condition index (CI), *P. viridis* was found to be a sensitive but tolerant organism to Cd, Cu, Pb and Zn. The byssus (BYS) of *P. viridis* was found to be a sensitive biomonitoring tool for Zn whereas its total shell was a good biomonitoring material for Cd and Pb. Allozyme polymorphism of *P. viridis* was found to be a potential biomarker for metal contamination. Simple indicators (aerial exposure and shell deformities of *P. viridis*) for heavy metal pollution were also identified.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENILAIAN KUPANG *PERNA VIRIDIS* (LINNAEUS) SEBAGAI AGEN PENUNJUK BIOLOGI KEPADA KADMIUM, KUPRUM, RAKSA, PLUMBUM DAN ZINK UNTUK PANTAI BARAT SEMENANJUNG MALAYSIA

Oleh

YAP CHEE KONG

Februari 2003

Pengerusi : Profesor Madya Ahmad Bin Ismail, Ph.D.

Fakuti : Sains dan Pengajian Alam Sekitar

Sedimen sampel (46 kawasan) dan kupang *Perna viridis* (19 kawasan) di pantai barat Semenanjung Malaysia telah disampel di antara 1998 dan 2001 dan dianalisis untuk Cd, Cu, Hg, Pb dan Zn. Tahap logam berat tersebut di sedimen adalah (luar-pantai : pasang-surut) 0.75 ± 0.06 : 0.86 ± 0.11 µg/g berat kering (bk) untuk Cd, 4.27 ± 0.36 : 29.22 ± 8.84 µg/g bk untuk Cu, 38.87 ± 2.93 : 60.10 ± 9.47 ng/g bk untuk Hg, 17.36 ± 0.99 : 23.32 ± 3.39 µg/g bk untuk Pb dan 37.22 ± 2.01 : 84.64 ± 12.62 µg/g bk untuk Zn. Tisu lembut *P. viridis* didapati di antara 0.25-1.35 µg/g bk untuk Cd, 6.31-20.21 µg/g bk untuk Cu, 20.00-152.00 ng/g bk untuk Hg, 1.27-8.76 µg/g bk untuk Pb dan 53.82-135.50 µg/g bk untuk Zn. Kesemua tahap logam tersebut adalah rendah berbanding dengan data di sekitar rantau ini. Secara keseluruhannya, tahap logam berat di sedimen pasang-surut adalah lebih tinggi daripada sedimen luar-pantai. Kajian geokimia menunjukkan bahawa 58.6 : 57.7% untuk Cd, 53.3 : 46.3% untuk Cu, 72.6 : 54.3% untuk Pb dan 34.5 : 48.7% untuk Zn, bagi sedimen luar-pantai dan pasang-surut, adalah disebabkan oleh aktiviti manusia. Namun begitu, tahap logam berat yang tertumpu di lokasi yang tertentu

menunjukkan bahawa pantai barat Semenanjung Malaysia telah menerima logam berat hasil daripada aktiviti manusia di lautan dan daratan.

Dengan kaedah alozim protein, differensi genetik di antara pelbagai populasi geografi didapati di dalam julat populasi 'conspecific'. Disebabkan *P. viridis* bertaburan luas di kawasan persisiran pantai barat Semenanjung Malaysia, mempunyai corak hidup yang tetap dan tahap differensi genetik yang rendah, spesies ini adalah agen penunjuk biologi yang baik kepada kawasan tersebut. Kupang *P. viridis* yang disampel di dalam lapangan juga menunjukkan logam berat di dalam tisu lembutnya berkolerasi positif dan signifikan ($P < 0.05$) dengan Cd, Cu dan Pb di persekitarannya yang diwakili sampel sedimen.

Melalui esperimen-esperimen yang dijalankan di dalam makmal, tisu lembut *P. viridis* didapati berkebolehan menumpuk logam berat yang tinggi terutamanya Cd, Pb dan Hg. Ini menunjukkan kesesuaian *P. viridis* sebagai agen penunjuk biologi kepada logam berat tersebut. Kajian depurasi juga menunjukkan tahap logam di pelbagai tisu lembut berkolerasi secara signifikan ($P < 0.05$) dengan air laut. Dengan menggunakan mortaliti, kadar filtrasi dan 'condition index', *P. viridis* didapati adalah sensitif tetapi ia adalah organisma yang bertoleransi tinggi terhadap Cd, Cu, Pb dan Zn. Kajian ini juga mendapati bisus *P. viridis* adalah lebih sensitif sebagai organ penunjuk kepada Zn manakala keseluruhan cangkerang *P. viridis* adalah bahan penunjuk biologi yang baik kepada Cd dan Pb. Alozim polimorfisma bagi *P. viridis* adalah penunjuk biologi yang berpotensi bagi pencemaran logam berat manakala penunjuk biologi yang mudah (pendedahan udara dan cangkerang *P. viridis* yang abnormal) bagi pencemaran logam berat telah dikenalpasti.

ACKNOWLEDGMENTS

I am most indebted and grateful to my supervisor Assoc. Prof. Dr. Ahmad Ismail who had guided me along the way towards the completion of this doctoral degree. He had given me a lot of constructive comments, advice and ideas. With his support and motivation, my research activities were conducted efficiently and on time.

Also, I would like to extend my sincere gratitude to Prof. Dr. Tan Soon Guan who has guided me for the protein allozyme study of my work and also taught me a lot on how to write good scientific papers. His time, kind and constant encouragement are very much appreciated. My appreciation also goes to Dr. Hishamuddin Omar for his kind support. Thanks to the Japan International Cooperation Agency (JICA) and Malacca Straits Research and Development Centre (MASDEC) for organizing the scientific expedition cruises in the Straits of Malacca. The isozyme work was supported in part by IRPA grant 01-02-04-0074 which is also highly appreciated. My thanks are also extended to the Fisheries Institute at Batu Maung, Penang, for providing the strain of *Isochrysis galbana*.

My thanks are also extended to Abu Hena, Khai Khin, Nik, Sem, Kak Rosniza, Hamid Rezaei, Ali Mashinchian, Mr. Hidir, Kok Kuan and all my friends who indirectly contributed so much towards this achievement.

TABLE OF CONTENTS

LIST OF TABLES